

TRACE ELEMENT AND NUTRIENT CYCLING IN SAN FRANCISCO BAY

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LONG TERM GOALS

Our goal is to make quantitative measurements of the fluxes of trace metals (copper, cobalt, cadmium, manganese, and iron) and nutrients (ammonia, nitrate, phosphate and silicate) and gases (oxygen, carbon dioxide and ^{222}Rn) into and out of the sediments of shallow water embayments and harbors. We seek to understand the coupling between organic matter diagenesis, pore water chemical profiles, infaunal activities, and the mobility of trace metals across the sediment-water interface. We seek to investigate metal-nutrient interactions utilizing *in situ*, manipulative experimentation. These measurements will be used to develop a predictive model of chemical cycling whereby the magnitude of the anthropogenic contributions of dissolved metal and nutrient species within a coastal system can be addressed. Further, we seek to advance the technologies available to conduct *in situ* research into shallow water sediment diagenesis and benthic biological impacts on sediment and water quality.

OBJECTIVES

Our initial objective was to study the behavior of metals within coastal sediments under a variety of environmental conditions. We identified the following near-term objectives: 1) Determine the variability of fluxes within the LA Harbor system, 2) Establish the variability of reactions involving nutrients and metals within Harbor sediments, 3) Conduct manipulation experiments to examine the influence of various environmental parameters on trace metal-nutrient coupling. These objectives were met with research conducted in 1994-1996. We continue to examine these questions and add as further objectives for 1997-1998, 4) Study the relationship between bloom/non-bloom conditions in San Francisco Bay regarding sediment diagenetic reactions and fluxes, and 5) Build and test a new benthic incubation device which will facilitate bio-chemical manipulation experimentation on the sea floor. This work is supported by ONR Chemical Oceanography.

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APPROACH

We approach these objectives from a field-research orientation. We have conducted research cruises within LA Harbor and San Francisco Bay and collected water column samples, sediment cores from which we extract pore water, and utilized benthic flux incubation chambers to measure transport rates directly. From the water column data we determine the standing stock of chemical species within the system. The pore water data are used to study the depth distribution of nutrient and metal reactions and to establish the diffusive gradients between pore waters and overlying water. The benthic flux chambers are used to incubate areas of the sea floor, *in situ*, and establish the rate at which chemicals cross the sediment-water boundary. Nutrient and metal measurements are made on roughly 10 water column samples, 30 pore water samples and 20 chamber samples per deployment, per site within LA Harbor. In 1997 we visited San Francisco Bay in May and July and conducted chamber flux, pore water and water column measurements at 5 stations.

We have built, tested and utilized a new incubation chamber. This new chamber is transparent, hence day-night light availability differences may be accounted for and tested. The new benthic chamber allows for 3 injections of spiked solutions or solids to the incubated volume in contact with the sea floor and it has a lid which can be programmed to open or close allowing the chamber to exchange with ambient water or behave as an incubation cell. We added a robotic coring device which is capable, upon programmed command, of subcoring the sediment contained within the incubation chamber. We also adapted an autonomous nutrient analyzer to continuously draw small sample volumes from the chamber and analyze and record the nitrate concentration.

WORK COMPLETED

The new benthic chamber has been constructed tested and we have compared fluxes measured with the new chamber to fluxes measured with our old chamber. We have conducted side-by-side comparisons of flux measurements at two sites in San Francisco Bay. All the components of the new flux chamber (opening-closing lid; spike injection system, sample draw system, robotic coring device, in situ chemical analyzer) have been tested and operated flawlessly in San Francisco Bay. Diver-collected push cores have been collected at all chamber deployment sites and pore waters recovered on a cm scale by sectioning and centrifugation under a nitrogen atmosphere. Cores collected by the robotic corer from sediment incubated within the flux chambers have also be sampled for pore waters in order to track the distribution of Br tracer down-core. Water column nutrient, metal and dissolved gas concentrations have been measured.

A thesis (M.S.) has been completed by a graduate student at USC (T. Townsend) in which the distribution of Br tracer within a benthic chamber and within sediment pore water has been modeled with respect to different transport mechanisms and rates.

RESULTS

We learned previously that biological activity within coastal sediments acts to enhance the exchange rate of nutrients and trace metals across the sediment-water interface, well above the rate supported by diffusive transport. This result holds true for San Francisco Bay sediments as well.

Side-by-side comparisons of fluxes measured with the new chamber and the old chamber produced excellent agreement. Nutrient fluxes measured in May 1997 indicated greater biogenic matter degradation rates relative to measurements conducted in July. This is consistent with the hypothesis that biological productivity, enhanced during the spring bloom (March/April), finds its way into the sediment within weeks and undergoes rapid degradation. We will be investigating the hypothesis that the presence of *Potamocorbula* sp. (an exotic species) results in an increased efficiency of particle scavenging. The very high rate of dissolved silica flux from bay sediments in the May chamber experiments were suggestive that the spring bloom may have been dominated by diatoms, an hypothesis which was supported by data supplied by USGS biologists (J. Thompson, pers. comm.).

Numerical simulations of tracer disappearance from a benthic chamber have shown that bio-irrigation is pumping water into and out of a chamber at a rate, at some LA Harbor sites, of greater than 750 ml/minute. The simulation modeling is also capable of distinguishing deep irrigation systems from shallow irrigation systems. We are presently comparing observed tracer data from chambers and from cores retrieved from within chambers, with computer simulations of different irrigation scenarios.

IMPACT

This research supplies important baseline information regarding nutrient and trace metal fluxes into and out of the sediments of San Francisco Bay and LA Harbor. It identifies methodologies that may be implemented in environmentally sensitive areas and used to identify actual exchange rates of solutes across the sediment-water interface. It will also enable us to assess the environmental consequences of dredging, remediation, exotic species infestation, and nutrient loading on metal release from sediments. It allows us to distinguish the difference between flux rates in unperturbed and perturbed environments. Our work with benthic incubation chamber technology is in the forefront of this field and will lead to collaborations between bioremediation and biogeochemical researchers.

TRANSITIONS

We are making a smooth transition between the collaborative research effort in LA Harbor (collaborators K. Coale and K. Johnson at Moss Landing) and work in San Francisco Bay. Some data is still being worked up and we are in the process of writing manuscripts describing our results. Our work with benthic chamber development and new technologies certainly could be adopted by and is willingly offered to benthic

geoscientists at various Navy Laboratories. There is a possibility that environmental groundwater industries may be interested in utilizing benthic chambers for investigations of toxic solute fluxes from contaminated groundwaters into coastal marine sediments.

RELATED PROJECTS

The USC and MLML groups will continue to work closely with the ongoing research in SF Bay. The work described above has been entirely collaborative between these two groups. Additionally, we have collected samples for the ONR funded group at Old Dominion University (J. Donat and D. Burdige). For the SF Bay project we are working closely with Ken Bruland (UCSC) and the ODU group to coordinate field efforts and possibly share samples. We have also been working closely with scientists at the USGS-Menlo Park (J. Thompson, J. Kuwabara) assessing benthic conditions at new and previously occupied sites and conducting collaborative sampling for sulfide and DOC analysis.

REFERENCES

M.S. Thesis: Numerical simulations of tracer loss from benthic chambers: An investigation of bio-irrigation rates and patterns in marine sediments. (T. Townsend, USC, 12/97)

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